*International Journal on Applications in Information and Communication Engineering*
*Volume 7 : Issue 2 : July 2021 , pp 49 –55 www.aetsjournal.com* ISSN (Online) : 2394 - 6237

# MONITORING FRUIT FRESHNESS DURING TRANSPORTATION

**Dr.R.Subramanian, Sujitha Devi M, Ebin Ephrem, S.Sureshkumar**
Department of Electronics and Communication Engineering,
Rathinam Technical Campus, Coimbatore, Tamilnadu, India

*Abstract*— Every year, 104 million tonnes of perishable goods, including fruits and vegetables, are carried within India's cities, of which 100 million tonnes do so without refrigeration. If the quality of these products changes during shipping, there could be a financial loss or fruit damage. The use of sensor and Radio Frequency Identification (RFID) technology to monitor perishable fruits is currently widespread in the literature. However, these systems fall short of offering a whole strategy that takes into account energy usage and adherence to the temperatures required to preserve foods. The use of effective technologies, such as RFID and Wireless Sensor Networks (WSNs), to monitor the ripening status of fruits in order to prevent damage as well as to identify and track the precise presence of damage during transportation, is becoming increasingly necessary in order to resolve this issue. In this study, sensors and RFID were used to measure the quantity of ethylene content (the hormone that causes fruit to mature) produced by the fruits to assess their level of ripeness. The suggested method is distinctive in that it uses RFID tags with unique identifiers to determine the state of the fruits in each box. This makes it possible to monitor the fruit box's ripening stage without even opening it. In this study, an integration of WSN and RFID-based systems interfaced with Service Oriented Architecture (SOA) has been presented for attaining an effective real-time monitoring, control, and management of fruit freshness during transportation. By reducing system complexity and maintenance costs, this effort attempts to automate the fruit monitoring system. Suppliers with chains of warehouses, supermarket merchants, etc. may find it valuable.

***Index Terms***— RFID Tag, WSN, Fruit Quality Monitoring, Cloud Data Store.

## I. INTRODUCTION

The biggest obstacle to India's development is poverty, which is a contributing factor in many socioeconomic issues. India has one-sixth of the world's population, so if it doesn't end its own poverty, neither will the rest of the world. It is pitiful that India, a country that produces in prodigious quantities, is struggling with hunger and poverty. A third of the food produced worldwide—roughly 1.6 billion tons—is lost to human waste. Food waste is estimated to cost USD $1 trillion annually. When 870 million people's stomachs are empty and they are hungry before bed, a significant amount of food is wasted without being consumed. According to a 2010–12 Food and Agriculture Organization (FAO) report from the United Nations, one in eight people worldwide are undernourished. The amount of food wasted by high-production nations like India, which consumes the same amount of food as Australia in total, is 21 million tonnes of wheat. In India, between the grower and the consumer, 40% of the fruits and vegetables are wasted. If food was distributed effectively, surplus could be used to feed the underprivileged. Due to inadequate cold storage, weak supply chain infrastructure, and a lack of food processing in the agricultural sector, India loses 550 billion rupees worth of fruits and vegetables each year to wastage.

People throw food away even when it is edible due to poor consumer behaviour and a lack of communication in the supply chain, for example, the best-before date. According to the Food and Agriculture Organization (FAO) of the United Nations, this amounts to food waste in society. Without the production of food reaching every region and group of people in India, poverty cannot be eradicated.

There are commercial solutions for monitoring the trucks and containers, but they don't give all the information about the cargo, so they only produce the data occasionally or only at specific locations. The cold chain should be viewed as a single entity from harvest to consumer plate. It is not enough to improve one link in the cold chain to improve the system as a whole.

Therefore, a thorough approach that takes into account energy usage and adherence to the temperatures required to preserve foods is highly required. In this context, a great deal of control, management, measuring, and automation still needs to be developed.

A growing variety of measurements must be taken in the food supply in order to make an appropriate observation.

International Journal on Applications in Information and Communication Engineering
Volume 7 : Issue 2 : July 2021 , pp 49 –55 www.aetsjournal.com ISSN (Online) : 2394 - 6237

Offering suppliers and distributors continuous and accurate readings throughout the distribution process, specialised observation devices promise to revolutionise the shipping and handling of a wide range of breakable goods.

The main contributions of this research are as follows: (1) integrating RFID and WSN technologies to track the ripening state of the fruits during transportation; (2) proposing an integrated automated framework as a solution for an effective real-time monitoring of perishable fruits using Service Oriented Architecture (SOA); and (3) increasing the system's agility and reducing maintenance costs for food suppliers.

The background is described in Section 2 of the remaining text, and then Section 3 provides a summary of some of the related research that has been done. The proposed work's system model is illustrated in Section 4. The implementation steps, test results, and conclusions drawn from them are then expanded upon in Section 5. Section 6 comes to a close.

## BACKGROUND

The creation of smart devices and processes is made possible by recent advancements in information and communications technology. Through methods like aeration or defrosting, remote observation may prompt a necessary action to maintain the shipment's quality. Certain requirements, including robustness, low energy consumption, decent precision, affordability, and acceptable size and shape, must be met by the sensing devices.

New developments in wireless sensor technology have paved the way for inexpensive, compact sensors nodes that can work together. In order to monitor applications that involve sensing environmental factors like temperature, humidity, and pressure cost effectively, wireless sensor networks (WSNs) are widely used. These sensors have the capacity to create a network through which they can exchange information with other sensors and send it to a gateway [1].

A multi-hop wireless setup is required to forward the information to and from the gateway because a sensor with limited energy cannot communicate with it. This adds extra overhead and creates interference problems [2].

In order to classify and identify the items on which they are tagged, Radio Frequency Identification (RFID) is a wireless radio communication technology. When used in real-time applications, it is quick, simple to read, and saves time and labour costs. RFID tags are made up of a transponder and memory that can store information like manufacturer and product names, as well as environmental parameters like temperature, humidity, and the concentration of particular gases in the atmosphere. Without a direct line of sight, high frequency RFID readers can read the data on the tags [3].

WSN can be helpful for sensing in some applications where much more is required than just RFID identification and location. WSN can be used to perform the necessary environmental sensing, but location and identification remain important [4]. In order to effectively combine the capabilities of these technologies, both must be integrated [5]-[8].

## ASSOCIATED WORKS

The elaborate related works are described in the following section. According to Ruiz-Garcia et al., the use of various data technologies, such as the Global Positioning System (GPS) and wireless information transmissions, will allow for better tracking of fruits and vegetables that are transported in cool containers. The focus of this work is on the requirement for the creation of new intelligently based transportation systems that should be concerned with food safety and security [9]–[10].

The two fundamental wireless technologies, RFID and WSN, have a wide range of uses, including environmental observation, security and surveillance, healthcare, control, and management. In a wide range of WSN-based applications, the use of RFID technology has recently discovered a new method for the automatic transmission of sensed data. Despite the fact that RFID tags can transmit sensor data from a small number of sensors, it is very challenging to miniaturise and integrate complex sensors into the RFID chip. As a result, an affordable general-purpose multi-ID tag based sensor data transmission was proposed [11] with the intention of transmitting any type of sensory data.

Only indoor applications were used for RFID technology at first. In the modern era, RFID and WSNs are essentially combined to offer an enhanced tracking and monitoring system for outdoor applications. A Nondeterministic PushDown Automata (NPDA) model based on two heterogeneous architectures was presented in [12] in order to integrate WSN and RFID technologies. Here, it's important to pay attention to the model's complexity.

Additionally, RFID technology is used to identify and locate objects that are difficult for conventional sensors to detect. RFID, however, doesn't provide any information about the objects' state. Additionally, WSN facilitates multi-hop wireless communication and offers information about the state of the objects. Therefore, the system's overall functionality can be increased by integrating these two technologies.

Therefore, the combination of these two technologies will increase the system's overall usefulness. It is necessary to continue addressing the new integration challenges between RFID and WSNs [13].

Vegetables, fruits, meat, and fish are examples of perishable food items that pose an additional risk to the cold chain. These goods require transportation that is refrigerated. In order to guarantee the quality of these products for consumers, it is therefore necessary to monitor and control their conditions during storage and transportation. Despite the fact that Van et al. investigated the potential use of WSNs for the observation of fruit storage and transport conditions, it takes more time to develop, seems to be expensive to deploy sensors, and is challenging to achieve real-time interactions with the sensors, especially in a controlled environment like a refrigerated truck. [14]-[15].

Various environmental factors, including temperature, humidity, light intensity, and toxic gases inside the cold storage container, must be monitored, according to the literature review, in order to preserve the quality of the perishable food products in storage. It is claimed that by monitoring and examining the environmental parameters gathered from the sensor nodes placed at the proper locations inside the container, the quality and lifespan of the goods can be increased [16].

Customers also demand a certain type of food product with the highest quality in addition to health and safety concerns. Because the food product standard is exposed to a variety of risks during production, transport, and storage, quality losses result. To meet consumer demand, this is currently the food industries' biggest challenge. A major concern for the food industry could be extending the reasonable shelf life of perishable food products. [17] provided a description of the use of various wireless sensors in refrigerated vehicles to observe, determine, and communicate what occurs during the transport while keeping track of the conditions of biodegradable items.

However, the large volume of data produced by these sensor-based monitoring systems makes it difficult to maintain the data and increases the hardware costs associated with doing so. This context makes use of recent developments in RFID technology. By integrating with a pricing decision using an RFID-enabled tracking system, Wang developed a method for modelling the degradation of food quality in terms of dynamically known food quality options. Through its pricing strategy, this system enables food retailers to increase their profits [18].

In order to improve food logistics, Vergara et al. proposed using an RFID reader with launched gas sensing capability to monitor the climacteric fruit during transport, storage, and marketing while taking into account various factors like wetness, temperature, intensity, ethylene, ethanol, and acetaldehyde levels. The outcomes have demonstrated that the RFID reader may be a useful tool in the supply of fruit [19]. The proposed work is briefly explained in the section that follows.

SYSTEM FOR MONITORING FRUIT

The suggested system's goal is to track the quality of perishable fruits while they are being transported using effective technologies like RFID and WSN. Both a WSN and an RFID technology operate independently within a network.

Once data from all RFID tags and detector nodes is transferred to the common centre, the RFID and WSN combo operates at the software layer. In such situations, the successful operation of either RFID or WSN may require assistance from the other. For instance, the WSN uses the identification provided by the RFID system to locate certain objects, and the RFID system then receives additional information from the WSN, such as locations and environmental factors. The benefit of combining these technologies is the ability to create integrated hardware with all RFID and WSN operations and collaborations taking place at the computer software layer. Although they operate in a similar manner, RFID tags/readers and device nodes are physically isolated from one another, which should impede with communication. As a result, programming is added to communications to prevent interference. The suggested system has a hybrid architecture, as shown in Fig. 1, where RFID tags and detector nodes are physically different devices but are connected by a network and function independently. The fundamental benefit of a mixed architecture like this is that a hardware-integrated device does not need to be designed.

The suggested fruit monitoring system's hardware consists of an Arduino UNO, a MIFARE Classic 1K tag, temperature and CO2 sensors, an MFRC522, and a GPS receiver (GPS).

The Arduino UNO is a single-board microcontroller that is designed to enable the use of interactive environments or objects that have a wide range of inputs. To simplify programming and integration into various circuits, the hardware is either a 32-bit Atmel Advanced RISC Machines or an 8-bit Atmel Aboriginal Voices Radio (AVR) microcontroller-based free open-source hardware board (ARM).

*International Journal on Applications in Information and Communication Engineering*
*Volume 7 : Issue 2 : July 2021 , pp 49 –55 www.aetsjournal.com* ISSN (Online) : 2394 - 6237

Classic MIFARE 1K Tag

The MIFARE Classic 1K card is essentially a memory memory device, where the memory is divided into blocks and segments with simple access control security techniques. Process power on these GPUs is constrained. These cards are mostly used for electronic case, access management, company ID cards, transportation, and sports stadium ticketing due to their dependability and inexpensive cost.

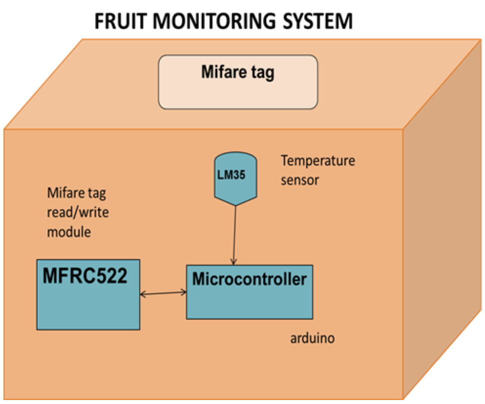


Fig 1. Fruit Monitoring System

SENSOR FOR TEMPERATURE (LM35)

The output voltage of the precise integrated-circuit temperature sensors in the LM35 series is linearly proportional to the temperature in Celsius (Centigrade). The LM35 is also superior to linear temperature sensors measured in Kelvin because it doesn't require the user to extrapolate a large constant voltage from its output in order to obtain convenient Centigrade scaling. The LM35 is capable of controlling temperatures between 55 and 150 °C.

CO2 Detector (MQ-135)

A carbon dioxide sensor, often known as a $CO_2$ sensor, is a device used to measure carbon dioxide gas. In controlled environment storage, high $CO_2$ levels have an impact on fruit quality, shelf life, and volatile fragrance compounds.

MFRC522

For contactless communication at 13.56 MHz, the MFRC522 may be an exceptionally integrated reader/writer IC. The ISO/IEC 14443 A/MIFARE mode is supported by the MFRC522 reader.

The inbuilt transmitter of the MFRC522 is prepared to power a reader/writer antenna made to communicate with ISO/IEC 14443 A/MIFARE cards and transponders without the use of additional active electrical devices. The Read/Write mode for ISO/IEC 14443 A/MIFARE is supported by the MFRC522 transmission module at different transfer speeds and modulation schemes. The receiver module offers a reliable and affordable implementation for demodulating and encrypting signals from cards and transponders that are ISO/IEC 14443 A/MIFARE compliant.

Location-based Services (GPS)

The Global Positioning System (GPS) is a space-based satellite navigation system that can provide precise location and time information in any part of the world with a direct line of sight to four or more GPS satellites. The system gives users in the military, civil sector, and business critical skills.

SOA and RFID middleware

Monitoring and managing devices is one of the fundamental services offered by RFID middleware. The data is actually extracted from the readers by RFID middleware, which then collects, filters, and transfers the data to the enterprise system. Actually, RFID middleware manages the data transfer between the MIFARE tags and the application software at the back end. RFID middleware can only support reconfiguration, though. As a result, a SOA-based integrated framework has been suggested in this work, with the main focus being on how corporate applications can call the services offered by RFID middleware over services interface layer. This framework makes it possible to turn the suggested system into a collection of connected services that can be accessed through a network as needed. By minimising the connectivity between devices and external software and simplifying the integration between middleware and applications, SOA implementation can further reduce system complexity [20]–[23]. As a result, the suppliers or warehouse workers can complete the following jobs swiftly and easily:

1) to keep an eye on the fruits' state of ripeness while they are being transported to prevent damage.

2) to locate and track any damage that occurred during shipping.

3) to establish the ideal temperature required to keep the fruits fresh throughout shipment.

4. To dynamically adjust the rate dependent on the fruit's quality.

RESULTS OF EXPERIMENTS

MIFARE tags are pre-programmed with product details including fruit kind, quantity, manufacturer, and any other data needed to identify the box. Each MIFARE tag has a specific ID that can be used to track the status of a box. Temperature, CO2, and O2 sensors provide readings of the box's interior temperature, respiration rate, and oxygen level, respectively. High-end RFID scanners could read these readings without a direct line of sight by writing them onto the MIFARE tag using the MFRC522 read/write module. The high end RFD reader periodically updates the database with this data. The status of the fruit is established using several Evaluation outcomes. Throughout the journey, the truck's current location is monitored using GPS. When the necessary storage conditions change and have an impact on the product's shelf life, a warning could be sent to the closest warehouse or shop.

After authentication, Figure 2 shows the outcome of reading and writing data to the MIFARE TAG.

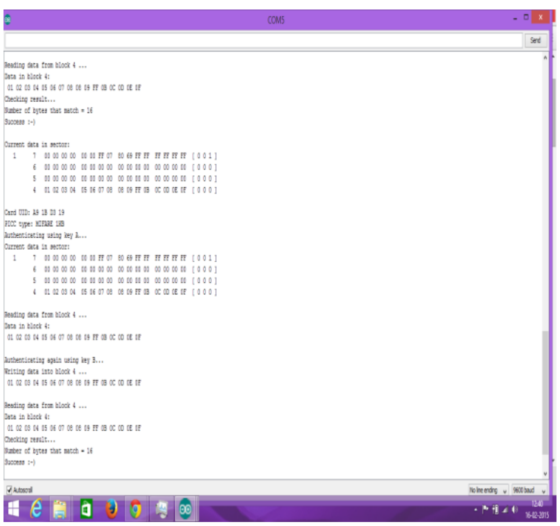

Fig. 2. Reading and Writing onto MIFARE Tag

Figure 3 represents the results of sensor data such as environmental parameters that are written onto to the MIFARE tag.

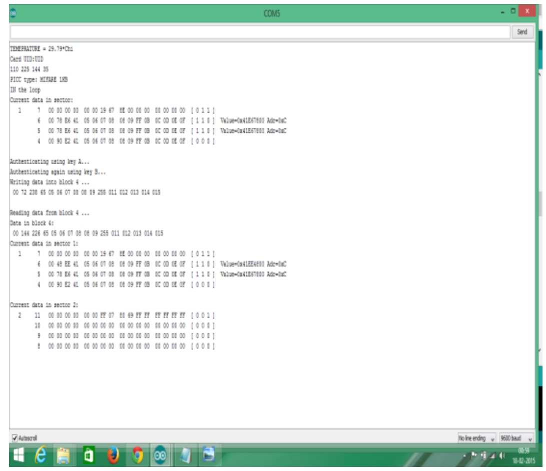

Fig. 3. Readings from sensor Written into MIFARE Tag

Figure 4 represents the results of GPS latitude and longitude reading required to trace the current location

A.

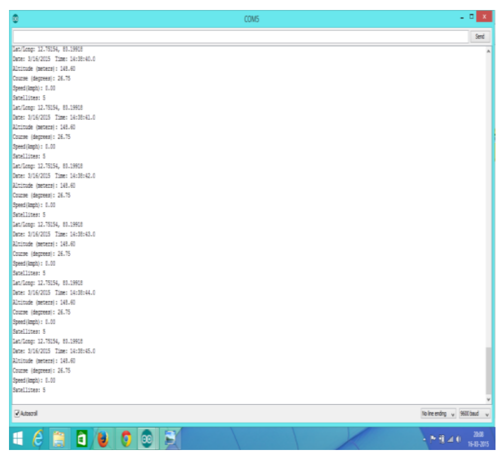

Fig. 4. GPS Latitude and Longitude Readings

The usual unit of measurement for respiration rates is the weight or volume of gas induced or consumed per kilo of fresh or modern product per hour. For instance: mg CO2/kg-h, cubic centimetre CO2/kg-h, or ul C2H4/kg-hr (i.e., per weight unit contemporary weight, hour) (i.e. per weight unit contemporary weight, hour).

The following sample data of evaluation results are used to assess the status of fruits. Data on CO2 and ethylene (C2H4) production for mango at various temperature ranges are shown in Table I.

AT DIFFERENT TEMPERATURES, CO2 AND ETHYLENE PRODUCTION FOR MANGO

| **Temperature** | **ml $CO_2$/kg·hr** | **ul $C_2H_4$/kg·hr** |
|---|---|---|
| 10°C (50°F) | 12-16 | 0.1-0.5 |
| 13°C (55°F) | 15-22 | 0.2-1.0 |
| 15°C (59°F) | 19-28 | 0.3-4.0 |
| 20°C (68°F) | 35-80 | 0.5-8.0 |

Table II contains the data about $CO_2$ and Ethylene production for apple at various temperature ranges.

$CO_2$ AND ETHYLENE PRODUCTION FOR APPLE AT VARIOUS TEMPERATURES

| **Temperature** | **ml $CO_2$/kg·hr** | **ul $C_2H_4$/kg·hr** |
|---|---|---|
| 0°C (32°F) | 2-5 | 1-10 |
| 5°C (41°F) | 3-7 | 2-20 |
| 10°C (50°F) | 5-10 | 5-40 |
| 20°C (68°F) | 12-25 | 20-125 |

These sample data are used to determine the best storage conditions for particular fruits so that they can be transported for up to two weeks or more without losing any of their nutritional value, as shown in Table III.

FOR STORAGE LONGER THAN 2 WEEKS OR MORE, CONTROLLED ATMOSPHERE

Vegetables and fruits

Storage Amount of heat (C) Level O2 ( percent ) Level of CO2 ( percent )

Apple

0-5 1-2 0-3

Apricot 0-5 0-3 0-3

Grapes 0-5 2-6 1-3

Mango

10-15 5-10 0-10

Orange

5-10 5-10 0-5

Tomatoes 12-20 3-5 2-3

With the aid of sensors, RFID readers, and GPS, any changes to these ideal storage conditions will generate an alert to another merchant nearby.

CONCLUSION

Using effective technologies like RFID and WSN, this suggested study keeps track on the quality and shelf life of fruits while they are being transported. Additionally, it has features that extend the shelf life of fruits while in transit, such as tracking products using GPS to deliver them to a nearby warehouse and identifying the specific box in which the fruits are about to spoil using a unique ID. Instead of using the sell-by date, an appropriate pricing model that takes into account the fruit's condition could be used.

## REFERENCES

[1]. Wireless Sensor Networks, University of Virginia Technical Report, June 2006, Charlottesville, Virginia, USA. J. A. Stankovic

[2]. Wireless sensor networks as a facilitator for cooperative logistic processes: C. Behrens, M. Becker, J. D. Gehrke, D. Peters, and R. Laur, Proceedings of the ACM Workshop on Real-World Wireless Sensor Networks 2006 (REALWSN'06), pp. 85–86, June 2006.

[3]. Overview of RFID technology and its applications in the food business, P. Kumar, H.W. Reinitz, J. Simunovic, K.P. Sandeep, and P.D. Franzon, J Food Sci., vol. 74, no. 8, pp. 101-105, 2009.

[4]. Australian Journal of Basic and Applied Sciences, vol. 9, no. 20, pp. 313-317, June 2015; S. Sasirekha, I. Joe Louis Paul, B. Prasanth, M.R. Pravinkumar, K.H. Srijish, and S. Swamynathan, "Automatic

Wireless Sensor Network Based Railway Safety System"

[5]. RFID and Wireless Sensor Networks by P. C. Jain and K. P. Vijaygopalan RFID and Wireless Sensor Network; retrieved on December 1, 2010 from http://www.scribd.com/doc/32593709

[6]. "Integrated RFID and sensor networks: architectures and applications," Aikaterini Mitrokotsa and Christos Douligeris, Zhang/RFID and Sensor Networks, Chapter 18, AU7777 C018, June 22, 2009.

[7]. I'm Ki Hwan Eom. International Journal of Multimedia & Ubiquitous Engineering, vol. 8, no. 4, pp. 343–352, 2013. Nghia Truong Van, Lin Sen, Kyung Kwon Jung, and Joo Woong Kim, "The Configuration of fruit state monitoring system using the RFID system."

[8]. International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC), vol. 1, no. 4, pp. 1-15, 2010. Bolivar Torres, Qing Pang, Gordon W. Skelton, Scott Bridges, and Natarajan

[9]. Meghanatha. "Integration of an RFID reader to a wireless sensor network and its use to identify an individual carrying RFID tags.

[10]. Span. J. Agric. Res, 5, pp. 142-156, 2007. L. Ruiz-Garcia, P. Barreiro, J. Rodrguez-Bermejo, and J.I. Robla, "Monitoring intermodal refrigerated fruit transit using sensor networks: A review"

[11]. Development of monitoring applications for the transportation of chilled perishable items, Luis Ruiz Garcia, PhD thesis, 2008

[12]. Sensor data transfer with passive RFID tags to feed wireless sensor networks: L. Catarinucci, R. Colella, and L. Tarricone, IEEE MIT-S International Microwave Symposium Proceedings, May 2010, pp. 1772–1775

[13]. "Model to integration of RFID into wireless sensor network for tracking and monitoring animals," Proceedings of the 11th IEEE International Conference on Computational Science and Engineering, pp. 125–131, 2008. D. P. Pereira, W. R. A. Dias, M. de Lima Braga, R. da Silva Barreto, C. M. S. Figueiredo, and V. Brilhante.

[14]. "Taxonomy and problems of the integration of RFID and wireless sensor networks," IEEE Network, vol. 22, no. 6, pp. 26–35, November–December 2008; H. Liu, M. Bolic, A. Nayak, and I. Stojmenovic.